



# Support for Moving Users through Thin Clients: Hype or Future?

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*Joint work of*

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## Outline

- Introduction
- Thin Clients
- Use Case: Thin Clients in Train Environment
  - Architecture
  - Network Connectivity
  - Context Awareness
- Conclusions



## Growing Mobility...

- Past Decade: increasing mobility
- Lots of mobile devices

*PDA*



*mobile  
phone*

*mp3-player*



*laptop*



## ... but still limited

- Devices must be small and lightweight >< multi-functional
  - TV on small-screen mobile
  - small keyboard on SmartPhone
- Short battery lifetime
  - laptop “power network” at meetings...
- Insufficient storage capacity
  - external hard-disk drives, USB-sticks
- Limited processing power
  - dedicated/lightweight OS for mobiles

*Thin Clients might offer an all-round solution*



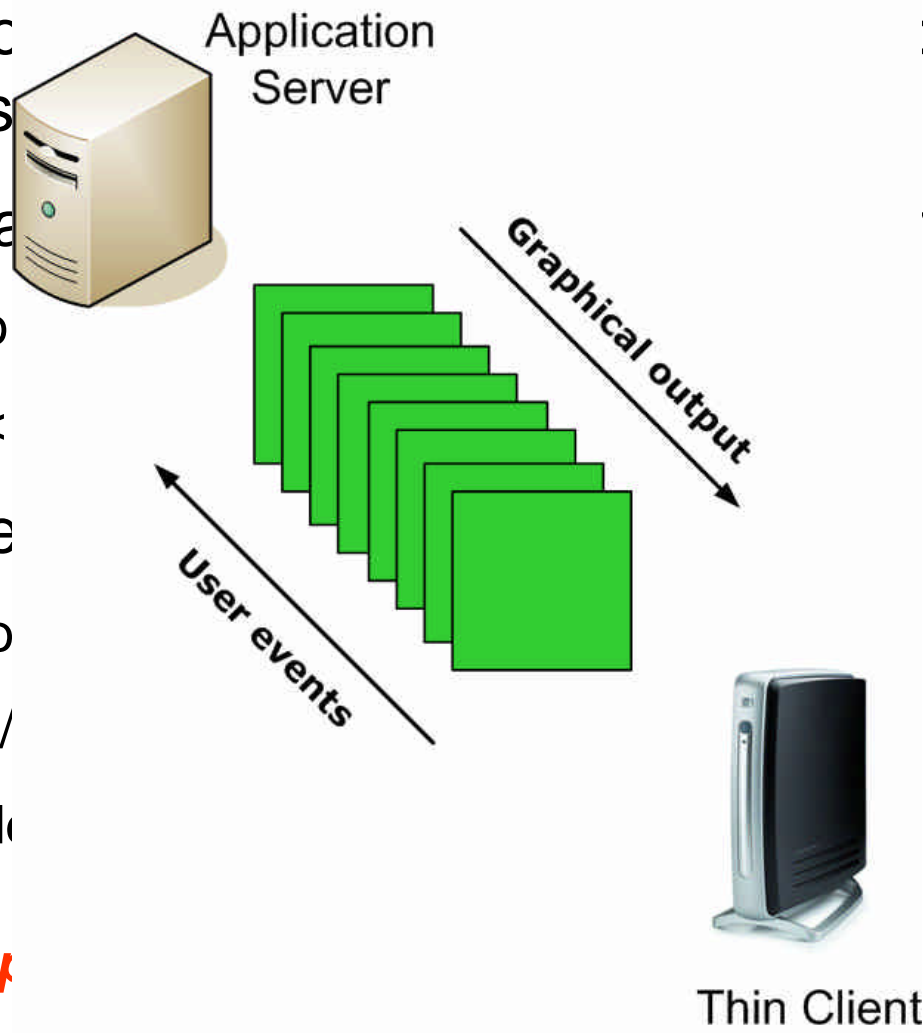
## Thin clients

- Applications are executed on remote server
  - continuous network connection required
- Display-only devices
  - no persistent storage
  - no locally installed applications
  - very limited local processing power
- Centralized computing, while maintaining benefits of a personal desktop
- Almost no local processing increases mobility
  - Weight reduction by removal of superfluous hardware
  - Extended battery lifetime
  - Virtually unlimited processing power and storage capacity offered by the network



# Responsiveness delay

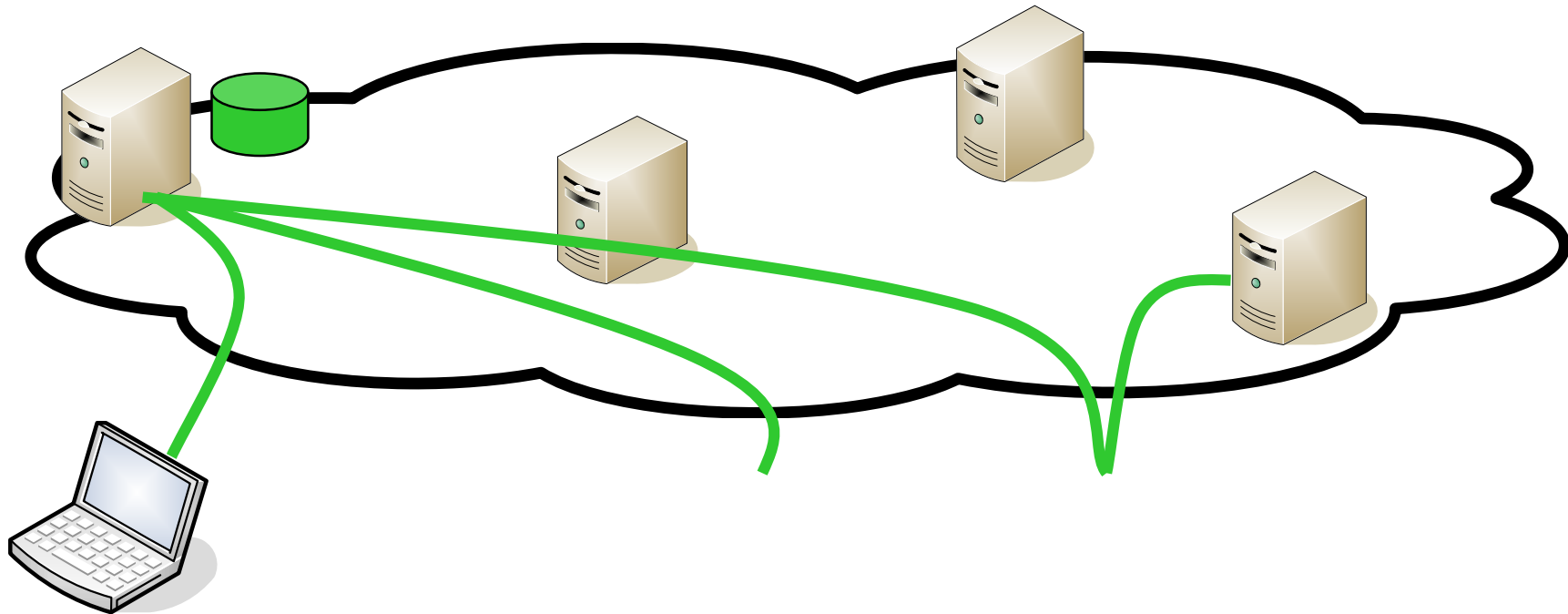
- Reactions can be perceived on the screen after at least 100ms
- Allowable latency depends on the application type
  - Text editing < 100ms
  - Gaming < 20ms
- Responsive applications are characterized by:
  - server processing
  - rendering/graphics
  - network delay



Application Server



# Application Migration



- Due to user movement, delay to server increases
- The application process is checkpointed
- Image is migrated to new server
- Application is restarted, user communicates with new server





## Server Selection Algorithms

- Application migrations are costly operations in terms of:
  - Resource reservation
  - Application downtime ( ~ seconds)
- In order to minimize the number of migrations, an efficient server selection is needed
  - user mobility patterns and prediction
  - max. allowable latency
  - network aspects
  - user preferences

**CONTEXT AWARENESS** enhances server selection





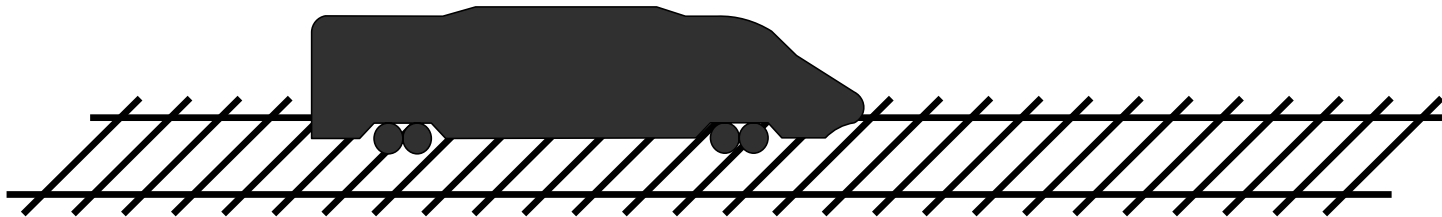
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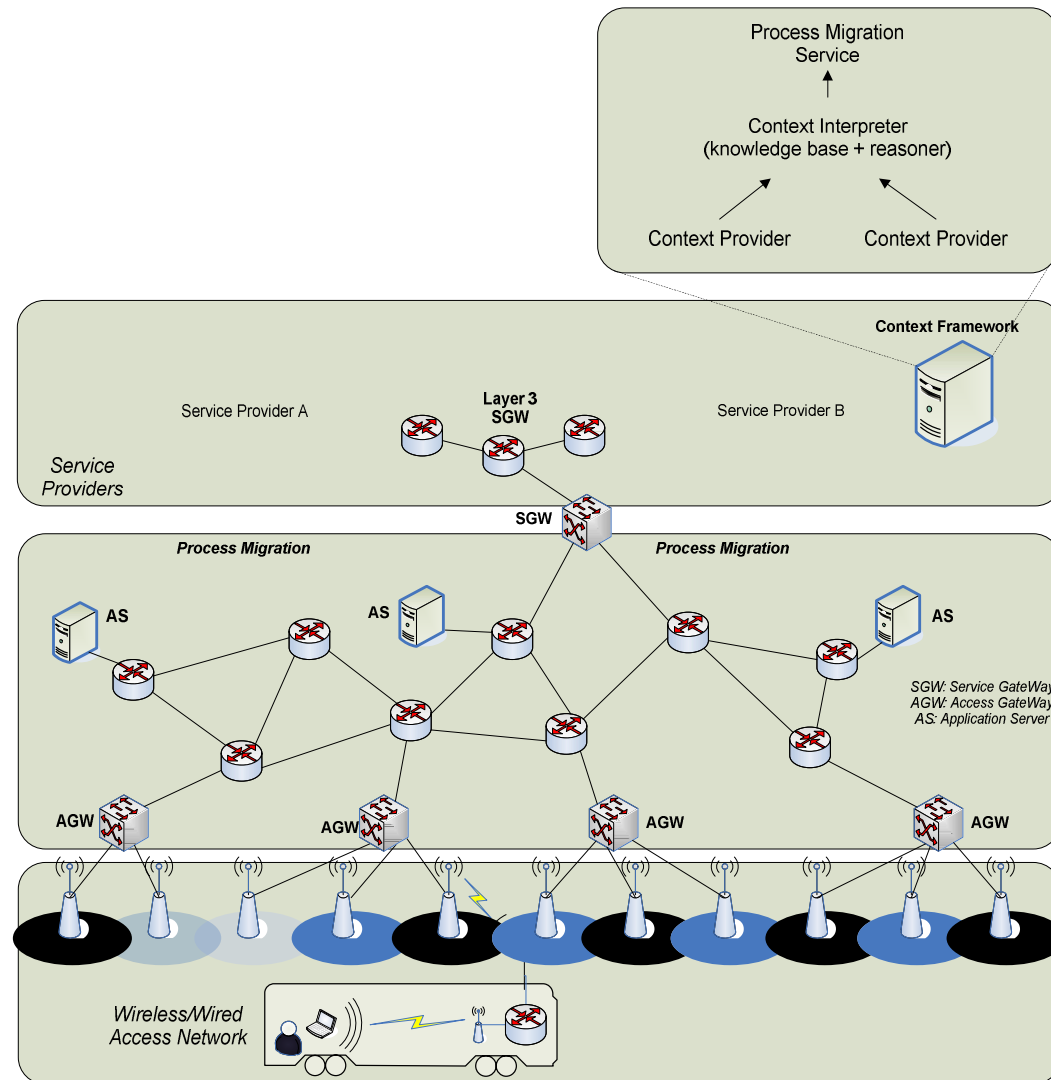
## Use Case: Thin Clients in Train Environment

- Commuters want to work or relax
  - Sending emails
  - Videoconferencing
  - Listen to music
  - Playing games
- Access to personal files and regular applications is needed





# Architecture



Aggregation of Context Information



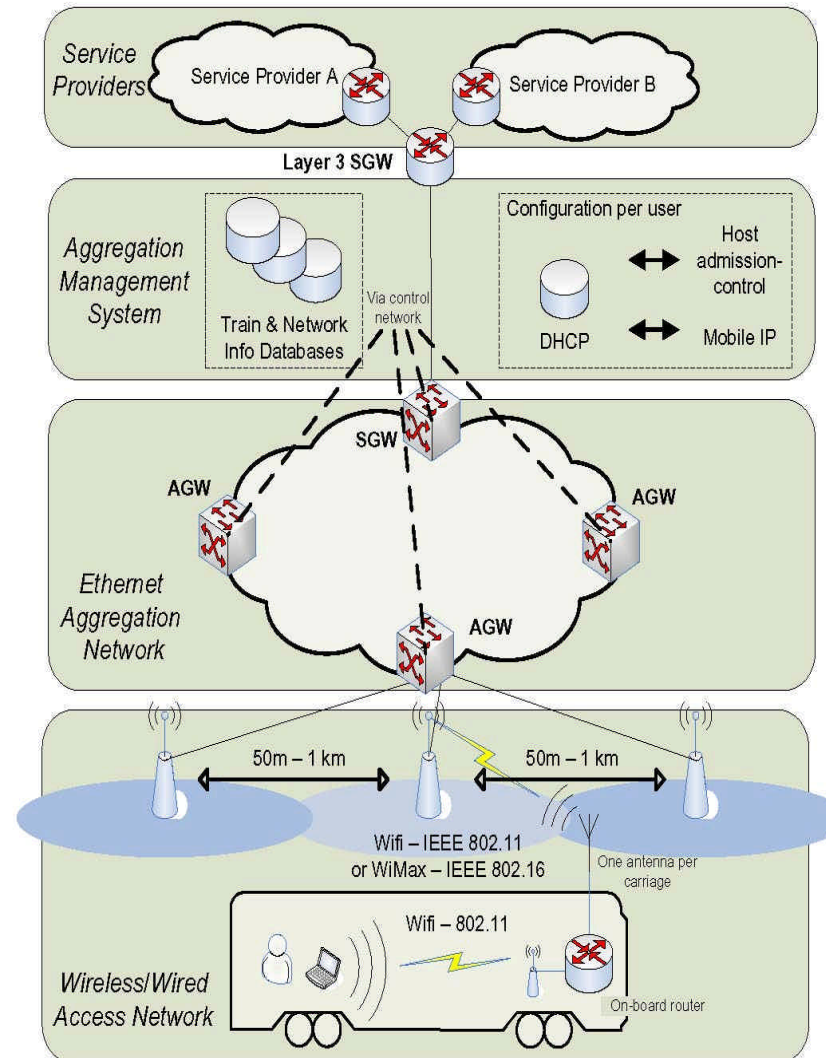
## Network Connectivity: Internet on the train

- Current technology deployments for delivering services to fast moving users
  - UMTS:
    - Limited bandwidth of cellular techniques
  - Satellite communication systems:
    - Suffer from intrinsic high roundtrip times i.e. two times the propagation delay between the earth and the satellite.
    - Upstream connectivity
    - High operational costs
    - Limited coverage in tunnels, stations and “urban canyons”
  - Wifi/WiMax based solution:
    - Handover issues
  - Most-likely near future architectures will be hybrid solutions
    - Satellite for more desolate areas
    - WiMax for urban areas



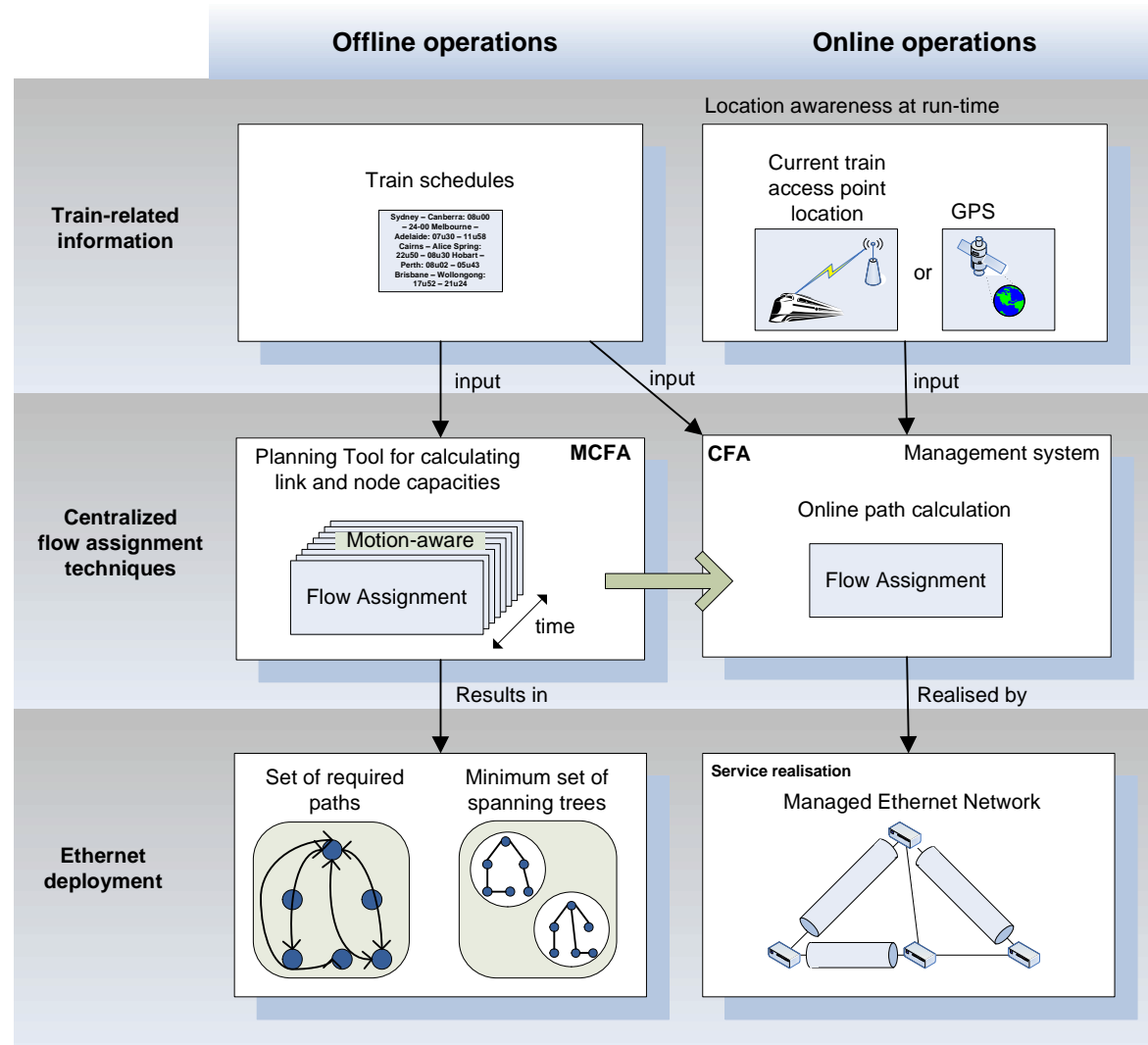
# Network Architecture

On-roof antenna architecture for WiFi/WiMax





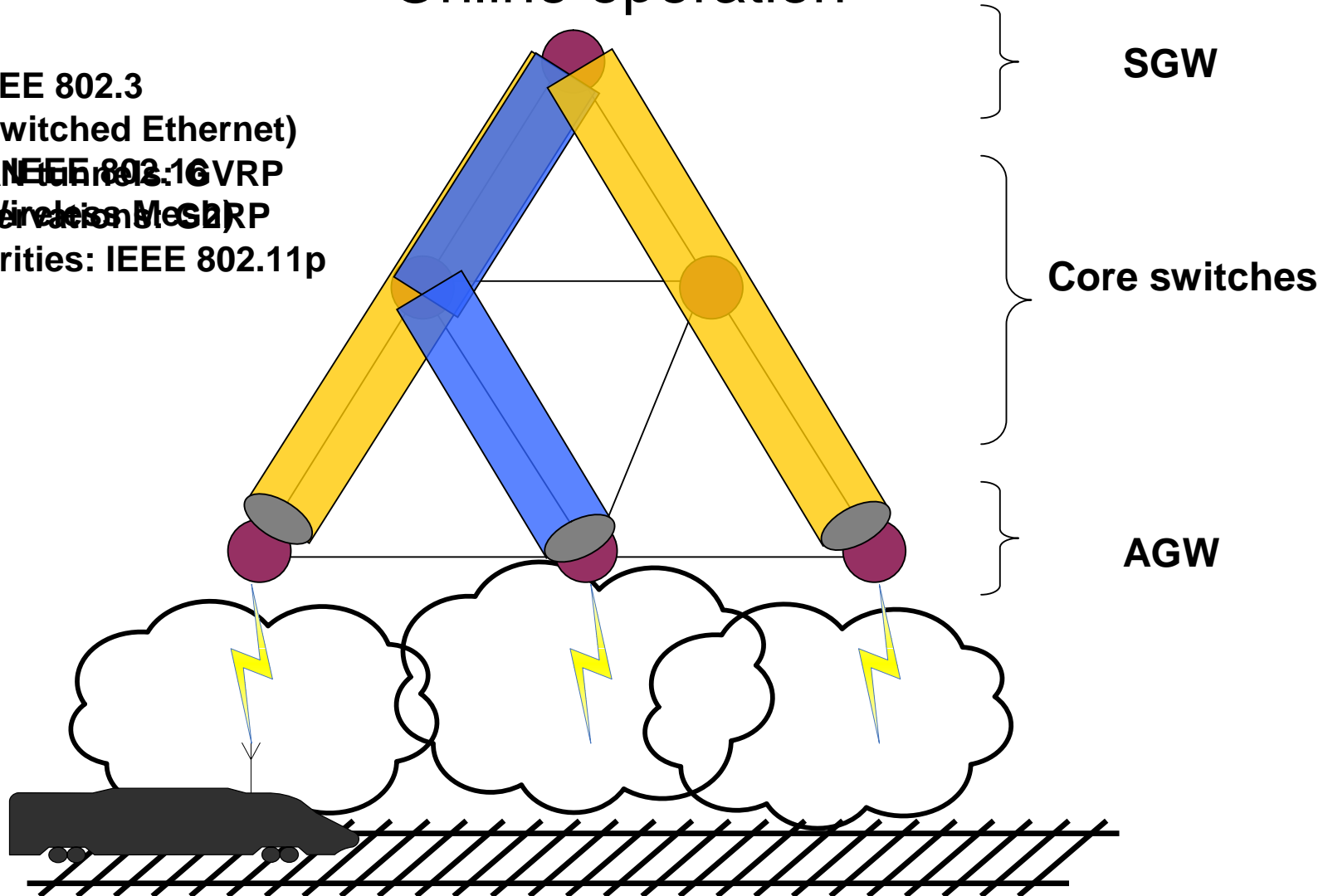
# Design approach





# Online operation

IEEE 802.3  
(Switched Ethernet)  
VLAN IEEE 802.1Q  
RRP (Wireless Mesh)  
Reservations (RSVP)  
Priorities: IEEE 802.11p







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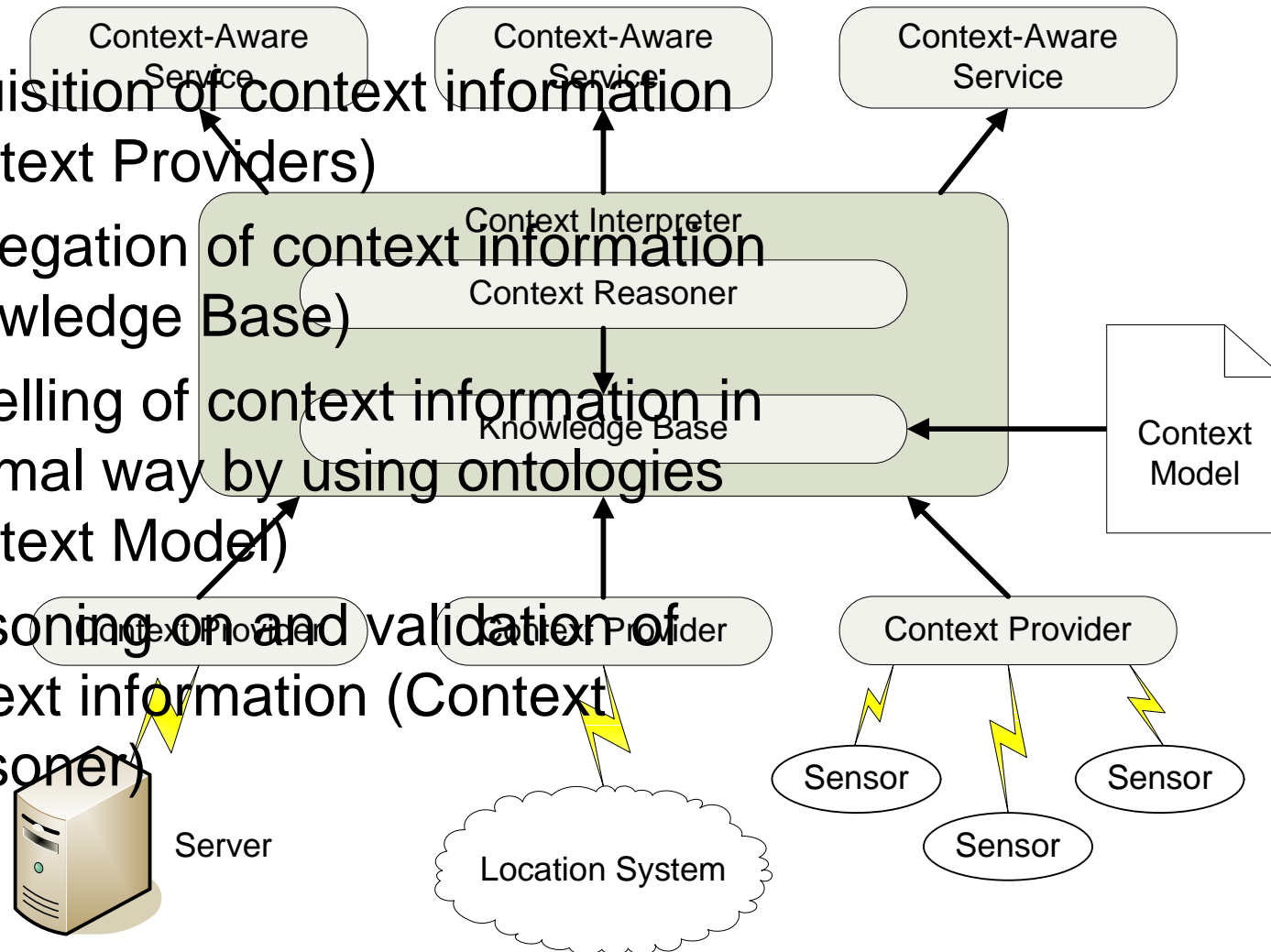
## Context Awareness

- “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves” [Anind K. Dey]
- Context-aware services automatically adapt to the environment taking into account:
  - Location info
  - User preferences
  - Network characteristics
  - ...



# Context Framework

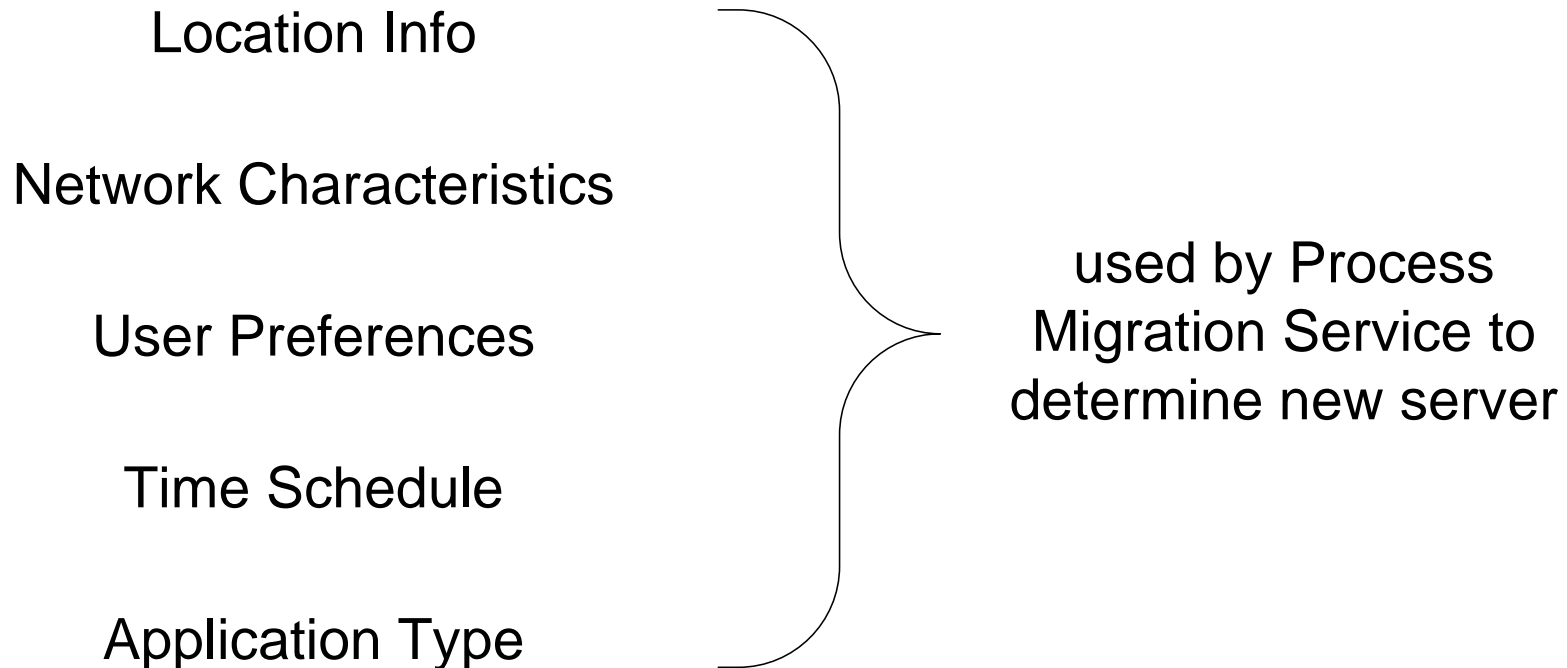
- Acquisition of context information (Context Providers)
- Aggregation of context information (Knowledge Base)
- Modelling of context information in a formal way by using ontologies (Context Model)
- Reasoning on and validation of context information (Context Reasoner)





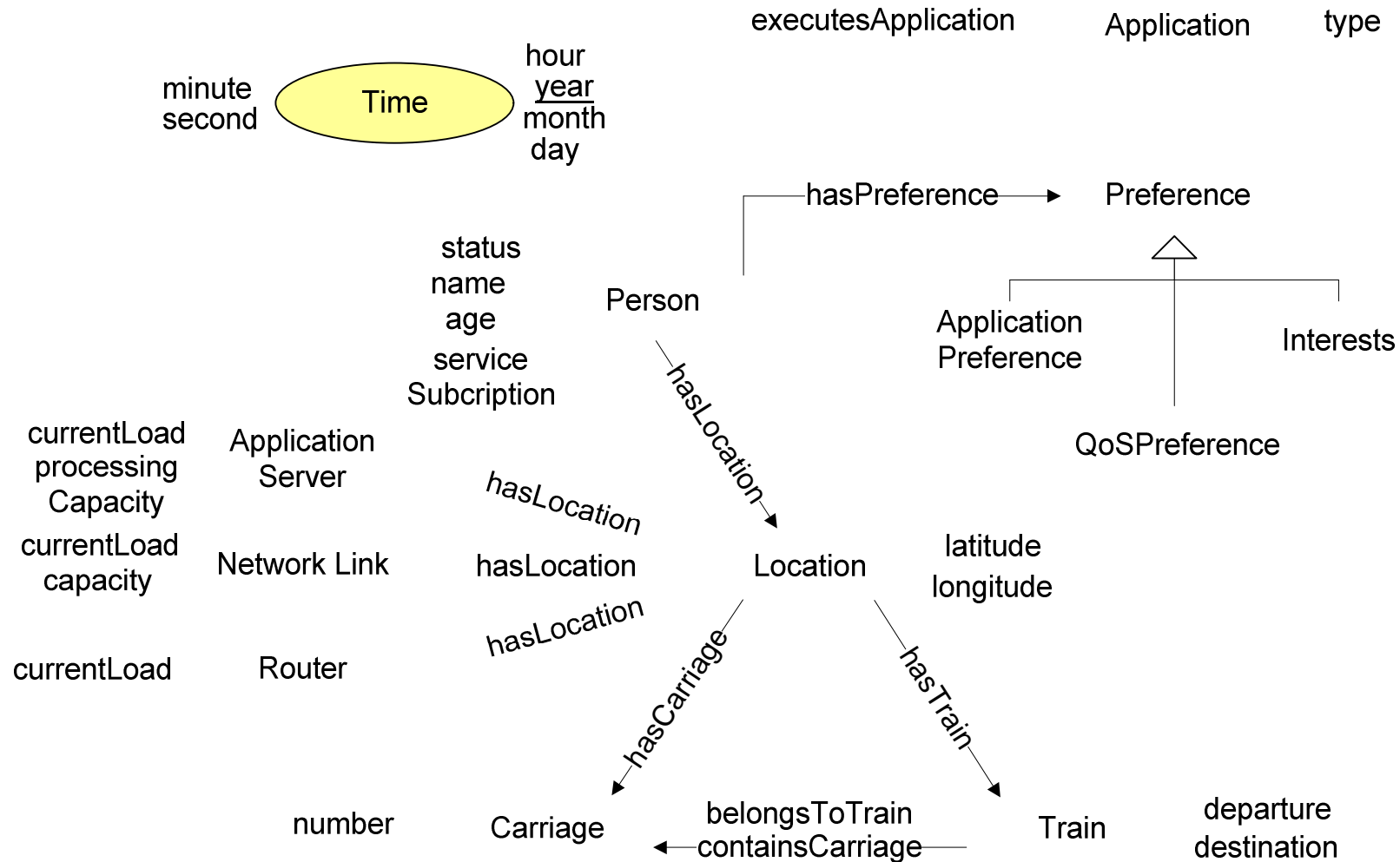
## Context information in train environment

- Server selection based on context information





# Context Model





## Conclusions

- Thin client mobility requires low latency
  - Application migration
  - Server selection
- Server selection based on context information
- Use Case in train environment
  - Continuous network access via Ethernet tunneling
  - Context aware platform presented



Thank you for your attention!

Questions?

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